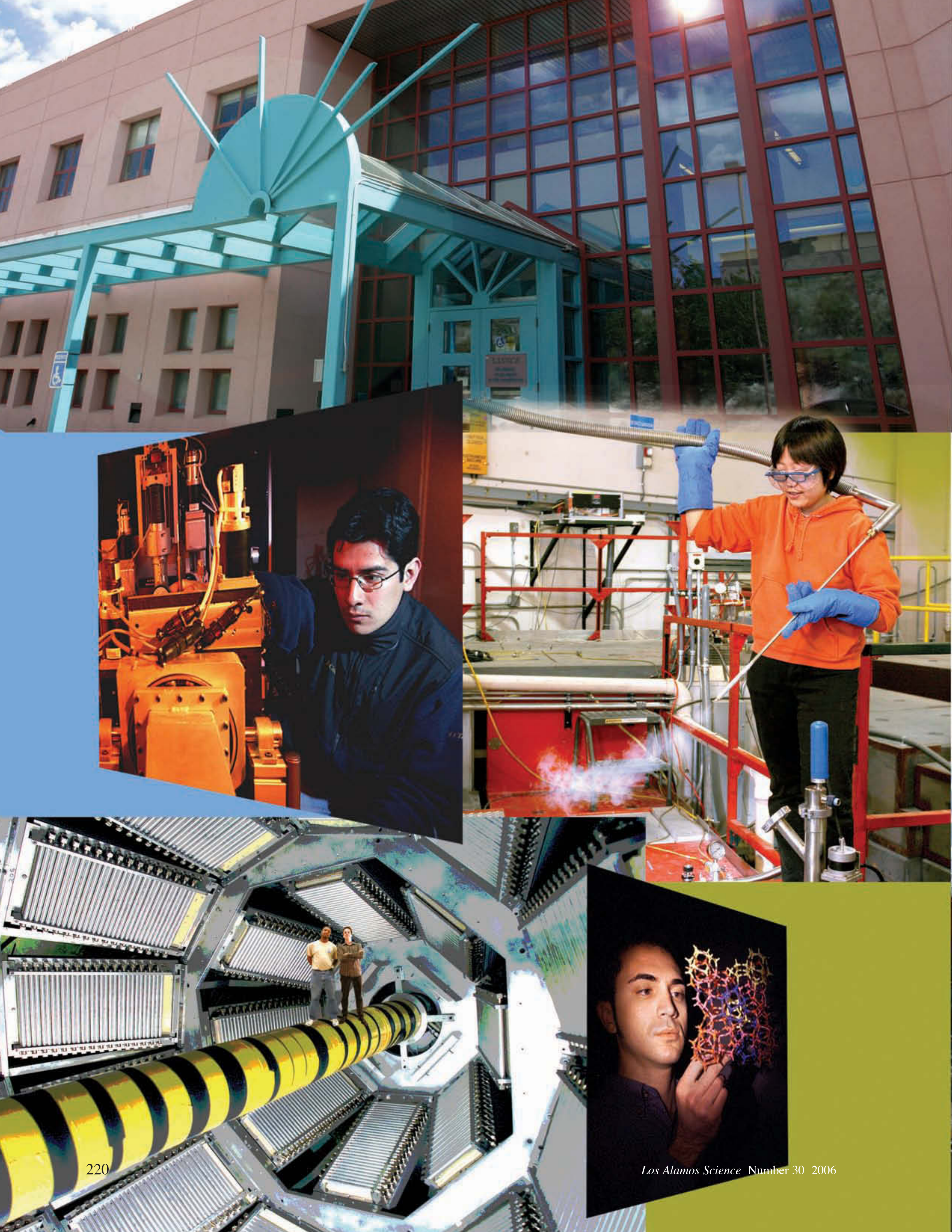


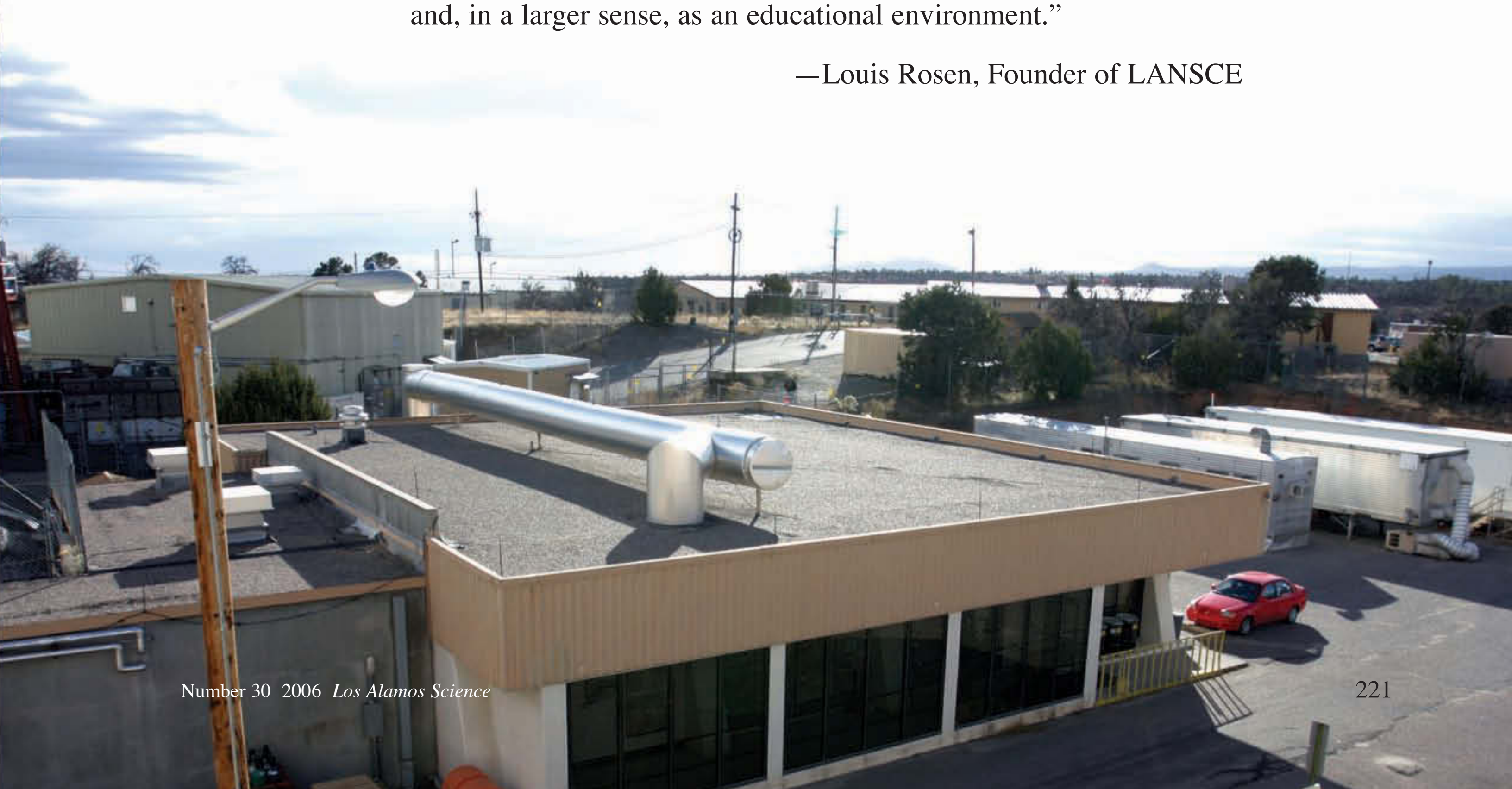
The User Program at LANSCE

Serving the Nation and the Laboratory

Allen Hartford, Jr.

"... we had to convince people that, in contrast to the rest of the Laboratory, [the Los Alamos Meson Physics Facility, LAMPF] would be open to all interested users. Users are involved in determining policy for upgrading the facility, for new beam lines, and for experimental programs, and of course, they are primarily and heavily involved in advising on the allocation of beam time. Although the users do not make the final decisions, they advise us on what scientific priorities should be assigned to various proposals. . . . LAMPF provides a great arena where faculty and students can together teach and practice the art and science of solving interdisciplinary problems. The very large number of publications and doctoral theses based on research at LAMPF attests to its excellence as an educational tool and, in a larger sense, as an educational environment."

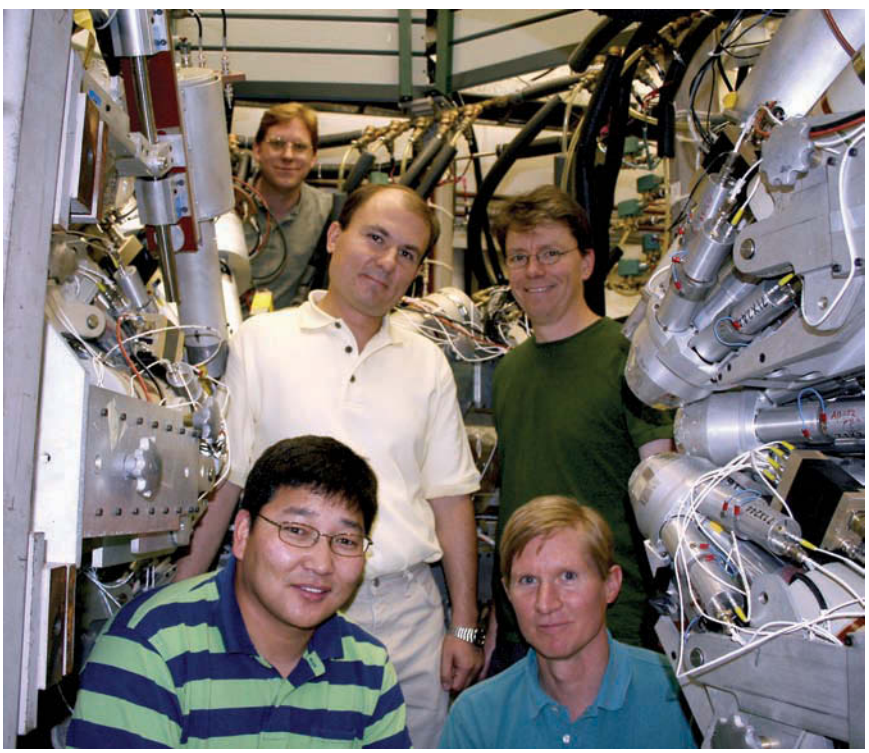
—Louis Rosen, Founder of LANSCE



For about 30 years, the 800-million-electron-volt (MeV) accelerator and its attendant facilities at Technical Area 53 (TA-53, often referred to as "the mesa") at Los Alamos National Laboratory have been a resource to an international community of scientific researchers. During its heyday, the Los Alamos Meson Physics Facility (LAMPF), as it was originally called, hosted about 1000 users per year. In 1977, the first pulsed spallation source was commissioned. Beginning in 1985, with the completion of the Proton Storage Ring (PSR) that compresses proton pulses from 750 microseconds to a quarter of a microsecond, the emphasis at TA-53 shifted to neutron science, and the facility became known as the Los Alamos Neutron Scattering Center and more recently (1995) as the Los Alamos Neutron Science Center (LANSCE) to reflect the broad base of research being conducted. In 2001, a Memorandum of Understanding among three branches of the Department of Energy (DOE)—the National Nuclear Security Administration (NNSA), the Office of Science (SC), and the Office of Nuclear Energy (NE)—and the Laboratory officially designated LANSCE as a national user facility.

Several key events have occurred during the last 20 years that have fostered the growth of the user program at LANSCE. In 1986, the Office of Basic Energy Sciences in the SC began providing funding for a formal user program in neutron scattering. In the same year, construction of a new experimental area, including office space, was begun and was completed in 1988. In 1996, the SC transferred responsibility for LAMPF to the Defense Programs (DP) of the DOE. Beginning in 1997, the SC, in partnership with the DP, began investing in the development of new instruments. Today, there are 14 active flight paths; seven are new since 2000 and two have been substantially upgraded.

Today, users conduct research at three major facilities at LANSCE: the Lujan Neutron Scattering Center (Lujan Center), the Weapons Neutron Research Facility (WNR), and the Proton Radiography (pRad) Facility. A nascent capability in ultracold neutrons (UCN) will be available to users in the near future. In the 2003–2004 run cycle at LANSCE, both the WNR and the Lujan Center achieved significant milestones by exceeding 500 users each for the first time. In 2005, the number of user visits at the Lujan Center was greater than during the previous run cycle. Proton radiography is a smaller effort in terms of users but is a vital element of the research conducted at LANSCE because of its focus on and contributions to the Laboratory's programmatic mission in stockpile stewardship.



Pictured here are GEANIE users, together with LANSCE staff. Left (front to back): Dugersuren Dashdorj —North Carolina State University and Lawrence Livermore National Laboratory (LLNL), postdoctoral fellow— Nikolaos (Nick) Fotiades—LANSCE, staff—and Robert (Rob) Macri—LLNL, postdoctoral fellow. Right (front to back): Ron Nelson and Matt Devlin —LANSCE, staff.

Importance of the User Program

The spectrum of capabilities available at LANSCE is not replicated anywhere else. Neutrons in the energy range from micro–electron volts to hundreds of million–electron volts are available, along with an array of instruments and detectors to utilize and analyze them. At the low end of the energy spectrum, ultracold and cold neutrons will allow fundamental physics studies, such as measurements of the electric dipole moment of the neutron with unprecedented accuracy and of the parity symmetry breaking in the weak interaction. Moderated neutrons in the milli-electron-volt to the electron-volt range are used at the Lujan Center with 12 spectrometers dedicated to research in materials science, condensed matter physics, structural biology, geoscience, and chemistry. Two beam lines in the Lujan Center are used for investigations in neutron nuclear science (including the aforementioned studies of parity violation). At the WNR, unmoderated neutrons (spanning energies from kilo–electron volts to million–electron volts) are used in nuclear science research, as well as in irradiating semiconductor devices, to understand the effects of cosmic-ray-induced neutrons. The WNR permits accelerated testing of these effects because the energy spectrum of the neutrons is similar to that produced by cosmic rays, but 5 orders of magnitude more intense.

These myriad capabilities and the LANSCE mandate as a national user facility attract a diverse array of users, both in terms of their research interests and their institutional affiliations. Most users come from universities, other national and federally funded laboratories, and industry. Because many of the university users are graduate students or postdoctoral researchers, LANSCE makes important contributions to the education and development of the country's next generation of scientists. Researchers from other federally funded laboratories conduct work that ranges from fundamental science to programmatic efforts, thus helping to ensure that the nation maintains a leading position in areas necessary for its continued well being. Among the results of industrial research at LANSCE are technological innovation and improvement in product reliability.

The demand for access to neutron sources is clear; LANSCE receives many more high-quality proposals than can be accommodated on the available beam lines and spectrometers. To respond to this demand, the country has invested in the construction of yet another facility, the Spallation Neutron Source (SNS) in Oak Ridge, Tennessee. Many of the scientists coming to LANSCE are introduced for the first time to neutron scattering. The Lujan Center, in particular, makes researchers aware of the versatility and power of this technique. Thus, LANSCE plays a pivotal role in training scientists who will continue to incorporate neutron scattering into their research and who will become part of the expanding user community.

The constant influx of users to LANSCE and the interactions with them benefit the Laboratory directly. Users help keep the Laboratory in touch with members of the external scientific community, who bring new perspectives and fresh ideas with them. In addition, many of the Laboratory's scientists have the opportunity to collaborate with the users and thus continue to be engaged in forefront research that hones their skills. A significant number of students and postdoctoral researchers who become familiar with the Laboratory through their experiences at LANSCE become part of the permanent workforce, joining many different technical organizations and making important contributions to the Laboratory's principal missions.

How Are Experiments Selected?

Individuals or teams who wish to conduct experiments at LANSCE must submit proposals. Calls for proposals are typically issued twice for each run cycle of the accelerator. Three program advisory committees (PACs) for materials, nuclear physics, and pRad have been established to evaluate the proposals. Each committee is further subdivided into subcommittees that evaluate proposals in specific areas. For materials and nuclear physics, most of the PAC members are from outside the Laboratory, many of them from the academic community. Because pRad is focused on the nuclear weapons program, most of the members of the PAC are from Los Alamos, Sandia, and Lawrence Livermore National Laboratories.

Scientific merit is the principal criterion for judging all the proposals submitted for beam time at LANSCE. Programmatic relevance is also considered in evaluating mission-driven proposals. Because proposals for pRad

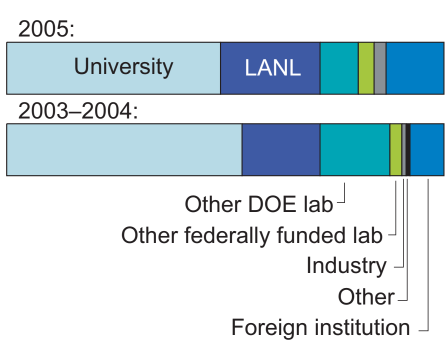


Figure 1. Lujan Center Users—Institutional Affiliations

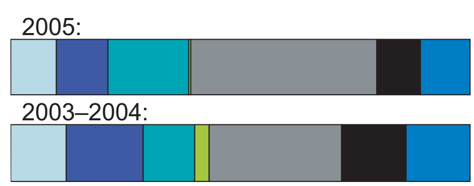


Figure 2. WNR Users—Institutional Affiliations

"I like to send my students to LANSCE because things are working smoothly. In the last three years, in particular, the beam line has been reliable, and the software is very well set up."

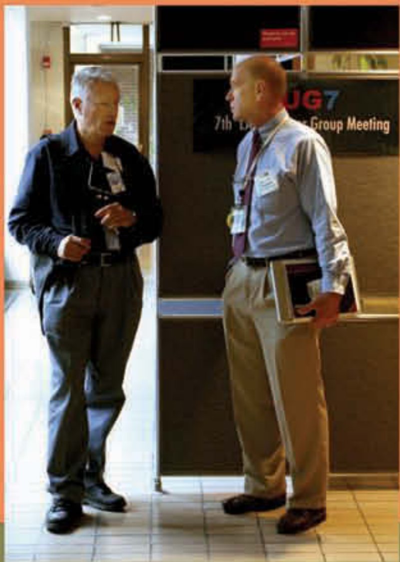
—Simon Billinge (right), Professor, Michigan State University

"The NPDF is exactly the instrument I need for my work. Being the world's best diffractometer of its kind, the NPDF generates data of exceptional quality. This time, I'll be using the NPDF for 12 full days. I'm up all the time, keeping an eye on the experiments and changing samples, but it's all worth it!"

—Emil Bodzin (left), Postdoctoral Fellow, Michigan State University

"The WNR is a unique high-intensity neutron source for the study of nucleon–nucleon physics over a broad range of energies. It has allowed many graduate and undergraduate students to experience firsthand the design, construction, performance, and analysis of nuclear physics experiments."

—June Matthews, Professor, Massachusetts Institute of Technology (MIT), and Director, MIT Laboratory for Nuclear Science



"Professor Peter Littlewood, director of the Cavendish Laboratory at Cambridge University, recommended that I use pair distribution function (PDF) to study the most fundamental nature of polycrystalline manganites. LANSCE has a very good setup for using the PDF—perhaps it's the best place in the world for experiments that use this method for very small scale ordering. Working with the people at LANSCE has been an extremely positive experience."

—Susan Cox (left), PhD Student, Cambridge University, United Kingdom

"LANSCE uses new technologies to answer controversial questions in biology. To do functional genomics, we need to know, for example, the locations of key hydrogen atoms. The Protein Crystallography Station at the Lujan Center gives us the power to look for those key hydrogen bonds."

—Chris Dealwis (above), Assistant Professor, University of Tennessee

"This was my first experience of LANSCE, and I would describe it as impressive. The neutron flux is high, and the furnace can be used at temperatures as high as 1250ºC. We need such high temperatures for our inelastic-neutron-scattering experiments. In 10 days of beam time, we conducted 30 runs "

—Rebecca Stevens, PhD Student, Caltech

Sunil K. Sinha (right), Professor, University of California, San Diego

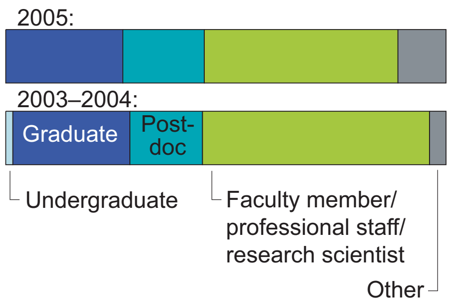


Figure 3. Lujan Center Users—Positions

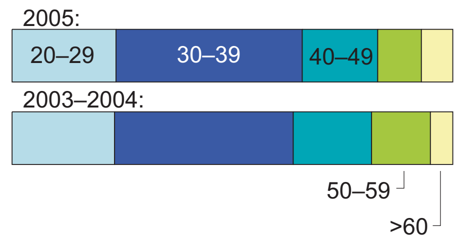


Figure 4. Lujan Center Users—Age Distribution (years)

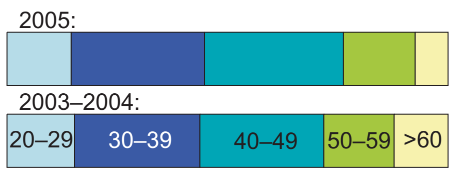


Figure 5. WNR Users—Age Distribution (years)

are highly focused on addressing programmatic requirements, mission relevance is an important factor in their overall evaluation. A measure of the overall high quality of all the proposals is that, for most of the beam lines and flight paths, we are unable to accommodate all the proposals recommended by the PACs.

Who Are the Users?

The users at the Lujan Center and the WNR are different in several respects, including the institutions they represent, their age distribution, and the number of students and postdoctoral researchers. Figures 1 and 2 show the differences in the institutional affiliation of the users at the Lujan Center and the WNR, respectively, for the 2003–2004 and 2005 (from February through September) run cycles.

Approximately half of the users at the Lujan Center are affiliated with universities, whereas most WNR users come from industry. The types of research conducted at the two facilities determine this obvious difference. The WNR enjoys growing numbers of users from the semiconductor industry, who test their latest devices for robustness against neutron-induced upsets. For instance, in the 2003–2004 and 2005 (through September) run cycles, 24 and 23 semiconductor manufacturers conducted experiments, respectively. Of these organizations, 15 were users during both run cycles, including major companies such as Advanced Micro Devices, AMD, Intel Corp., Sun Microsystems, Texas Instruments, and Xilinx.

By contrast, a relatively small fraction of the total number of users (approximately 10 percent) were members of the academia, who conducted nuclear science research at the WNR. These small numbers are likely related to a gradual decline in enrollment in this area at many universities. This trend concerns the Laboratory because of the Laboratory's ongoing need for nuclear scientists to support its primary mission.

At the Lujan Center, approximately 45 percent of the users are students and postdoctoral researchers conducting publishable research of a more fundamental nature (Figure 3).

The relative youth of the users is a remarkable strength of the user program at LANSCE. As shown in Figures 4 and 5, over 60 percent of the Lujan Center users and approximately 45 percent of the WNR users were below the age of 40 for both run cycles. Maintaining a strong component of students, postdoctoral researchers, and early-career scientists is a priority for LANSCE because we are fulfilling a mandate to help train and advance the next generation of scientific leaders, some of whom will join the Laboratory's staff.

Research Breadth and Diversity at LANSCE

A rather remarkable range of science is covered at LANSCE. Studies in materials science and engineering, geoscience, nanoscience, bioscience, condensed matter physics, chemistry, and soft matter are pursued at the Lujan Center. Resources available there allow research into systems subjected to extreme conditions, such as high pressure, high magnetic fields, high and low temperatures, large deformations, and extreme stress, many of these often in combination. Identification of a superhard carbon phase that results from squeezing carbon nanotubes to 75 gigapascals at room temperature (Wang et al. 2004) and the formation of a new clathrate molecule that efficiently stores hydrogen molecules (Loshkin et al. 2004) are only two examples of exciting new research from the high-pressure capability at the Lujan Center. Los Alamos scientists and external collaborators worked together on these projects. In addition, texture data for plutonium obtained on the high-pressure preferred-orientation (known as HIPPO) diffractometer at the Lujan Center have benefited weapons designers because grain alignment gives information about metallurgical structure and, hence, mechanical behavior.

At the WNR, research is conducted in areas such as nuclear structure, fission cross sections, neutron-induced reactions, neutron resonance spectroscopy, and neutron-induced failures in semiconductor devices. Researchers at the WNR have recently made important contributions to the nuclear weapons program by measuring neutron-capture and inelastic-reaction cross sections of radiochemical diagnostics—materials that were introduced into nuclear devices to measure performance during the nuclear-testing period. This information is being used to reevaluate archival nuclear data and to refine computational models. Improved measurements of fission cross sections are being conducted for both the nuclear weapons program and for evaluating advanced nuclear-reactor designs. Recently, a lead slowing-down spectrometer that increases neutron flux by over 3 orders of magnitude was developed to conduct measurements of very short-lived isotopes on very small samples. The size of the samples is determined by their high radioactivity and small abundance. Using smaller than 10-nanogram samples, LANSCE researchers recently conducted a proof-of-principle experiment, whose results were in good agreement with previous measurements of the plutonium-239 fission cross section. Another instrument, the Fast Neutron-Induced Gamma-Ray Observer (FIGARO), is used to measure neutron inelastic reactions and fission, the former being important for neutron transport calculations.

Thierry Granier has been a user at the WNR for several years. Thierry works at the Commissariat à l'Énergie Atomique (CEA) at Bruyères-Le-Châtel, France, and periodically comes to Los Alamos to use the FIGARO and LSDS instruments for fission measurements.

Proton radiography has proved to be a versatile technique for imaging dynamic events with high spatial resolution on submicrosecond time scales. It has been successfully used to investigate high-explosive detonation and burn, hydrodynamics and shock physics, and materials damage and spall, all-important phenomena in nuclear weapons.

Conclusions

The user facilities at LANSCE will continue to contribute to the science of the Laboratory for years to come. Materials research and neutron nuclear science are important elements of many of the Laboratory's programmatic responsibilities in national security, energy security, and basic research. Industrial research at both the WNR and the Lujan Center helps maintain the competitiveness of U.S. industry. Proton radiography is making important contributions to the certification of our nation's nuclear weapons stockpile in an era with no underground testing.

As a national user facility, LANSCE keeps the Laboratory in direct and permanent contact with the external scientific community, thus contributing to the Laboratory's scientific vitality. In addition, LANSCE exposes students and postdoctoral researchers to career opportunities at the Laboratory. Over 1200 people have joined the Laboratory in the last 25 years after having had a stint at LAMPF or LANSCE. Indeed, many of those people have contributed to the Laboratory's core mission. ■

Further Reading

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Wang, Z., Y. Zhao, K. Tait, X. Liao, D. Schiferl, C. Zha et al. 2004. A Quenchable Superhard Carbon Phase Synthesized by Cold Compression of Carbon Nanotubes. *Proc. Natl. Acad. Sci. U.S.A.* **101**: 13699.